

Utterance final lengthening and focus induced lengthening in standard Chinese bi-syllabic words

Abstract

This paper examines the patterns of durational adjustment of bi-syllabic words in Standard Chinese when different constituents of the word are focused for correction. Results show that both focus-induced lengthening and utterance final lengthening exists in Chinese bi-syllabic words. The distribution of final lengthening is non-uniform. The final-lengthening pattern of target words is progressive, while the focus lengthening doesn't have a certain pattern in lengthening, no progressive lengthening or any "edge effect" appears in the distribution of lengthening pattern. However both final lengthening and focus lengthening are consistent with the content based view and the structural based view. In that, lengthening appears in all syllables if it is expandable regardless of the where the lengthening starts. And short syllable lengthened less than full syllables. The lack of final lengthening in words with second syllable being stressed and a full first syllable agrees with the structure based view that lengthening starts from the stressed syllable. In the focus-induced lengthening, the target words position has a obvious impact on the lengthening effect. With greater focus-induced lengthening on words in the medial position than it is in the final position.

Introduction

Lengthening effect in utterance in certain situations has been noticed. Large amounts of studies have been done on the lengthening effects. It has been widely agreed that utterance-final lengthening and focused-induced lengthening play an important role in many languages.

Utterance-final lengthening means that the duration of utterance elements is always likely to be greater when they are in the final positions of an utterance than they are in the medial position. Focused-induced lengthening means that the duration of utterance elements is lengthened when focus is introduced on the elements. In this paper, utterance final lengthening together with focus-induced lengthening is being discussed, and also the lengthening patterns of both these two lengthening effects.

Previous Studies on Lengthening effects.

A lot of investigators have agreed that lengthening effects exist in many different languages. It is obvious that lengthening effects can be used by speakers to induce focus for listeners. This type of lengthening is called focused-induced lengthening. There is another type of lengthening – final lengthening that always happens in particular regions of utterances. This very important linguistic observation suggests that the utterance length of a syllable is longer when it is in the phrase-final position of utterances than when it is in the middle position of utterances (Oller, 1973; Lehiste, 1973; Klatt, 1975, 1976; Lehiste, Olive & Streeter, 1976; Cooper & Paccia-Cooper, 1980; Wightman, Shattuck-Hufnagel, Ostendorf & Price, 1992). It is termed as utterance-final lengthening or utterance-final lengthening. The observation of utterance-final lengthening raised a lot of other research interests. Some of them have proposed contrasting results that the lengthening does not only affects the phrase-final utterance constituents, but also affects some medial utterance constituents. In addition, other studies as Lindblom (1964, 1968), Lindblom & Rapp (1972, 1973). Lehiste (1972) and Huggins (1975), Turk & Sawusch (1997), Turk & White (1999), and Cambier-Langeveld & Turk (1999) suggest that the utterance duration of syllables can vary with the number of syllables in the word and can vary with the different syllable structures or word structures.

Prosodic hierarchy plays a very important role in lengthening as well. Prosodic hierarchy consists of different layers of linguistic constituents, the higher level of which are utterances, phrases and the lower level of which are words, syllables (Selkirk, 1978; Beckman & Pierrehumbert, 1986; Nespor & Vogel, 1986; Hayes, 1989). It shows that the degree of the lengthening affects is proportional to the positions of the utterance constituents in the prosodic hierarchy. (Wightman et al., 1992; Fougeron & Keating, 1997; Byrd & Saltzman, 1998). Although prosodic hierarchy is not developed to explain how hierarchy of the constituent structures affects the duration of utterance domains and distribution in the duration of utterance domains, the work on pause duration, utterance-final lengthening, initial lengthening suggests that the prosodic hierarchy does affect the duration and the distribution of the duration. That is, the influence of duration and the distribution of duration, when the pause duration, utterance-final lengthening and initial lengthening occurs at the boundaries of utterances, are higher in the higher layer of constituents than in the lower layer of constituents. Cambier-Langeveld & Turk (1999) explored the influence of prosodic hierarchy on accentual lengthening in Dutch and English. Accentual lengthening indicates that the phrasal prominence affects the duration of the constituents. This is easy to understand that, in both languages, the syllables of greater prominence (accented syllables) are lengthened. In addition, they suggested that the syllable right to the pitch accented syllable is lengthened more than the syllable left to the pitch accented syllable. And this influence of accentual lengthening only happens when the syllables are in the boundaries of utterances.

Utterance-final lengthening

Utterance-final lengthening is one of the research focus for those who investigate utterance lengthening. Speakers always use some cue signals in their speech, one of the way of signaling is lengthening (other way could be pause).

Utterance-final lengthening (usually referred as final lengthening) is the one of the most important lengthening methods speakers like to use. Utterance-final lengthening indicates that utterance duration of phrase segments (eg. syllables) in the final boundaries of phrase is likely to be lengthened. T.H. Crystal and A.S. House(1988) demonstrated that utterance-final lengthening is well populated in linguistic utterances. There is a deep correlation between the utterance duration of the phrase-final syllable and the boundaries of the prosodic structures. The study based on American English has suggested that the utterance-final lengthening is confined to the rime of the phrase-final syllable. Some possible domains for utterance-final lengthening have been proposed, such as, phrase-final coda consonants, phrase-final vowel, segments between the last stressed vowel and the phrase-final vowel, and the last stressed vowel. Moreover the structure of the phrase-final syllable also has influence on the size of lengthening. This utterance-final lengthening effect can happen not only on the phrase-final syllable but also the penultimate syllable.

Structure based view vs. content based view

Two major theories of utterance-final lengthening have been proposed, they are the structure-based lengthening and the content-based lengthening. Structure-based lengthening view supports that lengthening always happens in the boundaries of linguistic constituent structures no matter what content is in this structure domain. The boundaries of linguistic constituent structures can be words, syllables, or segments of a syllable in a fixed range of utterances. The structure-based lengthening view argues that the varying property of contents in this domain range doesn't change the systematic process of lengthening on the constituents in that domain range. Specifically, if the domain range is in the offset of a phrase, the lengthening process will happen in the phrase-final constituent structure. Klatt (1975) and in Wightman et

al. (1992) discussed lengthening of the phrase-final syllable. Their results supported the structure-based lengthening theory by saying that utterance-final lengthening process is structurally similar for all phrases in the utterance, although the phonological contents in the phrase-final phrase (for example, number of syllables of final phrase) can vary.

By contrast, there is a content-based lengthening view. It indicates that the varying content properties of the constituent structures of a phrase influence the utterance duration of different elements in the constituent structures. One of the hypotheses of content-based lengthening is the expandability hypothesis. Cambier-Langeveld (1997) has proposed that lengthening can occur on the earlier syllables if the phrase-final syllable cannot be expanded adequately. For example, if the phrase-final syllable is intrinsically short (eg. containing a short vowel), then syllables before the phrase-final syllable will be lengthened. In other words if the phrase-final element of phrase is expandable, then that phrase-final element is expanded. Otherwise, earlier elements should be expanded. The other hypothesis is the overlap hypothesis. This hypothesis introduced a concept of pi-gesture theory. Byrd and Saltzman (2003) proposed that the intrinsic length of its phrase-final segments affects the duration of gesture of phrase-final word. The pi-gesture theory states that clock of the onset and offset of a time period clicks slower. Pi-gesture overlaps differently on different portions of the phrase-final word. If the gesture duration for the phrase-final word is fixed and the phrase-final syllable is intrinsically short, the pi-gesture will overlap more with the earlier syllables of that phrase-final word. Therefore if the phrase-final syllable of a phrase-final word is gesturally short, then its earlier syllables are more likely to be lengthened. Both expandability hypothesis and overlap hypothesis have a similar prediction of the lengthening on the phrase-final word (that is, lengthening can vary based on the content properties of the phrase-final word), which is different from the prediction of

the lengthening resulted from the structural-based lengthening view.

Therefore, it becomes intriguing to investigate the utterance-final lengthening of linguistic utterances based on these two major theories (structural-based lengthening and content-based lengthening). In this study the two theories are tested to discover the influence they have on Chinese bi-syllabic words. In particular, special attention will be paid on phrase-final structures of phrase-final words. In addition, the two aspect of utterance-final lengthening are being investigated here: Where does the lengthening start? And how does the lengthening distributed among the syllables of the word? Turk and Shattuck-Hufnagel (2000) have explored these two aspects of phrase-final word lengthening. Here, studies related to final lengthening is being reviewed. More importantly, an investigation of these two aspects of phrase-final word lengthening in Standard Chinese is carried out since the final lengthening effect on Chinese has not been addressed adequately.

The start point of final lengthening

From the view of structure-based lengthening, the answer to the question of the start of the phrase-final word lengthening suggests that the lengthening is always happening if the word is in the phrase-final domain of a phrase, i.e., the utterance duration on the same word is longer when it is in the final position of phrases than it is in the beginning or medial position of phrases. It is so simple that, if the word in the final position of phrases, the word gets systematic lengthened. In contrast, the content-based view suggests that, for example, the number of syllables, the stress syllable in the words, and the phonological composition (short phrase-final vowel) of the phrase-final syllable will affect the start point of lengthening in the phrase-final word. The structure-based lengthening theory can be treated as a structural top level of influence on the whole word, while content-based lengthening theory, can be

treated as a functional level of influence on the components of the word.

Most of the researches that investigated the final lengthening of the final word of an utterance suggested that phrase-final syllable is lengthened. But this does not mean the lengthening begins at the phrase-final syllable. Some other researchers have explored the earlier syllables before phrase-final syllable and concluded that the lengthening begins at the stress syllable of the final word of a phrase. The studies supporting this conclusion include Kohler (1983) for German, Cambier-Langeveld (1997, 2000) for Dutch, Krull (1997) for Estonian, and Berkovits (1994) for Hebrew. Although all these above studies show that the utterance-final lengthening starts from the main-stress syllable (doesn't have to be the structurally phrase-final syllable) of the final word of a phrase, Still some other researches have conflicting results to this conclusion, especially in English, that main-stressed syllables do not always have lengthening in the phrase-final words. For instance, Wightman et al. (1992) reported there is no noticeable lengthening before the phrase-final syllable of the final word of a phrase based on studying in a corpus of a radio news in American English. But the reason might be the object of study(a corpus of a radio news) is not a good choice for locating start point of phrase-final word lengthening, because most of the words of the radio news have no earlier stress syllables other than phrase-final syllables(that is, all main-stress syllables are phrase-final syllables. This is actually consistent with the hypothesis of the utterance-final lengthening begins from main-stress syllables). Then some studies of the utterance-final lengthening on Southern British English also disagree with the hypothesis that the utterance-final lengthening begins from main-stress syllables. Cambier-Langeveld (2000) found some words (e.g. Johnny and Joseph) which have penultimate main-stressed syllables and the penultimate main-stressed syllables are lengthened. And then the study of White(2002) shows that the some words in Southern British English(like masonry) which have stress on the antepenultimate(ma-) syllable only have

lengthening in the last two syllables(-son- and -ry) instead. Other than the conflicting studies that some utterance-final lengthening does not start in the main-stress syllables, other studies have shown that the lengthening can start in the earlier syllables before the main-stressed syllables of a phrase-final word. One of these studies shows that in German, an unstressed syllable of a phrase-final word has the possibility to be lengthened although the magnitude of lengthening is less than that of the main-stressed syllable. (Silverman, 1990)

A discussion is being made here on both the structure-based view and content-based view. From all the studies, the utterance-final lengthening is found to be consistent with structure-based view. Utterance-final lengthening happens in all the phrase-final word regardless where the lengthening begins (phrase-final syllable, main-stress syllable or even unstress syllable). Most studies support that the lengthening starts at the stress syllable of the phrase-final word. This is also consistent with the structure-based view.

As for the content-based lengthening view, the theory works well with the words as Johnny and Joseph. Although structure-based lengthening view can be applied to these words as well, that the lengthening starts with the penultimate main-stress syllables and the lengthening continues to the phrase-final syllables. In the content based view, the lengthening starts from the syllables earlier than the phrase-final syllables because the vowel in the phrase-final syllable is phonetically short. Sometimes when the vowel of the phrase-final syllable inherently requires less jaw movements and this phrase-final shortening will push the beginning of utterance-final lengthening to the earlier syllables. The content-based lengthening view is also supported by Cambier-Langeveld's work in Dutch (1997). He suggested an expandability-based view, that lengthening starts before the phrase-final syllable only if the phrase-final syllable is phonetically short and this earlier lengthening will not happen if the phrase-final syllable is phonetically long. In addition, a Pi-gusture

view presented by Byrd and Saltzman (2003) is also consistent with content-based lengthening view. The point of pi-gesture is that pi-gesture will overlap greater with the earlier syllables if the phrase-final syllables are phonetically short.

From the corpus of literature review, the study of final lengthening in different languages and choice of different type of words in a same language will add more weight on utterance-final lengthening. In this paper, Standard Chinese is being chose as the object language with two-syllable words being the target words. Specifically, we will try to choose the words with the main-stress located in different syllables and the words with the vowels in the phrase-final syllables containing different phonetic length (phonetically long or short). The variations of the stress pattern and phrase-final vowel phonetic properties will help to explore the two major utterance-final lengthening theories (structure-based and content-based lengthening view). Target words with differences of location in stress can be used to test the structure-based lengthening view if final lengthening starts with the main-stress syllables. And the variations of the phrase-final vowel phonetic properties (long or short) will offer help in testing the content-based lengthening view if lengthening begins earlier if the vowel of the phrase-final syllable is phonetically short.

Distribution of final lengthening

Other than the studies of the start point of the final lengthening in the phrase-final words (two major views are proposed: structure-based and content-based lengthening view), there is another research interests which concentrate on the distribution of lengthening in the phrase-final words. Two major distribution models are presented in accordance with the two major final lengthening theories: progressive lengthening model and multiple domain lengthening.

Progressive lengthening model

One hypothesis of lengthening distribution may be that the duration of lengthening is equally distributed in the whole word. However, most work has proved that this does not happen in most languages. Instead, a progressive lengthening model has been proposed from a lot of studies. It is suggested by the progressive lengthening model that the lengthening increases when it approaches to the end of the word. For example, if a phrase-final word has three syllables and the lengthening begins with the first syllable, the magnitude of lengthening of the first syllable is the least, the magnitude of lengthening of the last syllable is greatest and the magnitude of lengthening of the second syllable is medium. Studies supporting this suggestion includes: research on German words (of at least three syllables) with penultimate main-stress syllable and found that the phrase-final syllable has greatest magnitude of lengthening, the antepenultimate syllable (the syllable prior to the main-stress syllable) has the lesser magnitude of lengthening. (Kolher, 1983) Silverman's (1990) investigation on German words (e.g. umLAgern) also showed that the pre-main-stress syllable (um-) has lesser magnitude of lengthening than the stress syllable(LA). Berkovits (1994) found support for progressive lengthening in Hebrew. Her work focused on Hebrew words of two syllables and showed that codas proportionally have greater lengthening effect than nuclei. For instance, in word Dudik, the phrase-final syllable -dik has greater lengthening than the penultimate syllable although the penultimate syllable is the main-stress syllable. Progressive lengthening model suggests that the prosodic hierarchy also has influences on the progressive lengthening distribution. There are four levels of prosodic constituents, Pwd, Phonological Phrase, Intonational Phrase and Utterance. The prosodic hierarchy effects over progressive lengthening shows that least magnitude of lengthening occurs on Pwd, and the magnitude of lengthening successively increases to Phonological Phrase, Intonational Phrase and Utterance. Therefore, if the

phrase-final segment has greater magnitude of lengthening, the location of the phrase-final segment is more likely to be the boundary of prosodic hierarchic constituents. The greater magnitude of lengthening on the phrase-final segment indicates the upper hierarchic level of prosodic constituent this location of the phrase-final segment is in. Related studies supporting this suggestion include Cambier-Langeveld (1997) in Dutch, and Wightman et al. (1992) in English.

In sum, other than prosodic hierarchy effects, the progressive lengthening model suggests that, successive syllables have progressively more lengthening within the phrase-final word, and successive subcomponents of the phrase-final syllable have progressively more lengthening within the phrase-final syllable.

Multiple domain model

Some other studies proposed an other distribution of lengthening model which is called Multiple domain model. Multiple domain model is proposed because the phrase-final syllables of words can be shortened or lengthened less than the non-phrase-final main-stress syllables. When a word is divided into multiple of domains, the different lengthened domains is defined due to the fact that some the elements of those domains are lengthened more. Based on this, progressive lengthening can be viewed as that the phrase-final word has a single continuous domain where the lengthening occurs. However Cambier-Langeveld's (1997) study of 5 words in read laboratory speech in Dutch found that a phonetically short vowel in the phrase-final syllable will push the lengthening to the previous main-stress syllable, but the other components of the phrase-final syllable may still be lengthened. In the example words of mode and tandem, the 'd' in mode and 'n' in tandem are not lengthened, but the earlier elements ('mo' and 'ta') are lengthened and the latter elements ('e' and 'em') are lengthened as well. In these examples, there are two domains of lengthening: one domain of lengthening before and one domain after

certain elements ('d' and 'n').

The importance of distribution of lengthening study in standard Chinese

Although there are two different models of how utterance-final lengthening distributes among the phrase-final word once it has begun, both of them are consistent with hypothesis that the magnitude of lengthening is greater when the elements is closer to the utterance boundaries. Again, there is not adequate study of the utterance-final lengthening distribution in different languages. Thus, in this paper, the distribution of utterance-final lengthening in bi-syllabic words of Standard Chinese is investigated here. Although it shares a lot of similarity with other languages such as English and Dutch, Standard Chinese has many differences due to its own characters. One major difference is the distribution of lengthening in Standard Chinese functions differently to mark focus and prosodic boundaries due to the specific phonology of Standard Chinese. Therefore, the investigation of the distribution of final lengthening in standard Chinese will be particularly valuable in untangling the physiological, cognitiona-based and language-specific aspects of this distribution adjustment. (cf. Lindblom 1978).

For all languages, the utterance duration lengthening occurring in certain linguistic unit can be used to indicate this linguistic unit is focused. Some studies in English have showed that when a word is focused, the word is lengthened (Cambier-Langeveld 1999). In addition, if a syllable of a word is focused, the whole word is lengthened too (Cambier-Langeveld 1999 and Sluijter 1995). This proved that the lengthening happens on word level in English if it is induced by focus.

The studies of focus-induced lengthening in Swedish suggest a different lengthening distribution pattern to that of English. It has been observed in Swedish that, when the word (with three syllables) is focused, the lengthening starts with the

first main-stress syllable, and continues on to the second syllable, but lengthening doesn't occur on the third syllable. This suggests that the lengthening happens on a sub-word foot-size unit in Swedish (Heldner and Strangert 2001). Besides marking focus, utterance-final lengthening can also mark prosodic boundaries. Different prosodic boundaries affect the utterance-final lengthening in different ways. Cambier-Langeveld & Turk 1999, Turk & Sawusch 1997, Turk & White 1999, found that, in English, there are two ways of effects of prosodic boundaries on utterance-final lengthening. One is, the word boundaries have more attenuation effect on utterance-final lengthening than syllable boundaries; the other is, within one word, the left edge of stress syllable attenuates lengthening more than the right edge of the syllable. This study suggests that although it is commonly known that all prosodic boundaries have utterance-final lengthening effect on the linguistic units, different attenuation of the lengthening is introduced by different linguistic boundaries. Other studies showed another prosodic boundaries effect on utterance-final lengthening. For example, the same linguistic units have different magnitudes of lengthening when they are in different prosodic contexts (Fougeron & Keating 1997). Specifically, (Cambier-Langeveld 2000) in a phrase-final position, a focused word has less magnitude of lengthening from utterance-final lengthening than an unfocused word.

Thus, in languages like English, the focused-induced lengthening and prosodic boundary effects on the distribution of utterance-final lengthening are consistent with the view that if polysyllabic word is lengthened to mark a focus, the main-stress syllable of the word is lengthened and then the lengthening is over-spilled to the neighboring syllables. However for those languages which do not have word-level stress syllables as English does, what will be the anchor for the distribution of lengthening? One hypothesis is there is another linguistic constituent other than syllable to serve as the anchor. Another hypothesis is, there is no specific anchor for distribution of lengthening, ie., the whole polysyllabic word is lengthened.

Standard Chinese is one of the different languages from English and Dutch and is a good choice for the study of utterance-final lengthening. First, Standard Chinese does not have word-level stress syllable. As we mentioned before, there are two hypotheses for the alternative of word-level stress syllable as the anchor of distribution of lengthening. Standard Chinese is a good test bed for both the hypothesis that whole word is lengthened and the hypothesis that some certain internal linguistic constituent unit inside word serves as the same the word-level stress syllable. Second, Study of Standard Chinese will help us to understand universal affects of the utterance-final lengthening, across various languages. Many studies have been done in languages such as English, Dutch, and Swedish. Standard Chinese has different phonological characters that are controversial or different to those languages.

Previous work on final lengthening of Chinese

Some previous work has been done for utterance-final lengthening in Standard Chinese. First interesting finding is, if the utterance-final lengthening occurs in single syllable word, both onset and rhyme are lengthened. This suggests that the lengthening will be stretched to the whole word. Yiya Chen (2003) proposed additional supports to this view that all the syllables of the word are lengthened no matter the word has a stress on a syllable, on a foot within the word, or the whole word. Aside from the suggestion that all the syllables of the word are lengthened, the second interesting research interests is, how is the lengthening distributed in the domain of lengthening in Standard Chinese? Since there is no main-stress syllable in Standard Chinese words, there won't be any similar conclusion in English, as for example, lengthening starts in the main-stress syllable and over-spilled to its neighboring syllables.

However, various studies have shown that prosodic structures influence the distribution of lengthening domains in Standard Chinese.

One suggestion is, the magnitude of lengthening is getting greater from left to right of a polysyllabic word no matter what are the relations between the syllables of the word. That is, the right most syllable of the word will be the most prominent, or the right most foot within the word will be the most prominent.(Chao 1968, Feng 1998, Duanmu 2000).

In contrast, another suggestion supports the view of trochaic footing that the trochaic foot (the first and third syllable of a four-syllable word) should be lengthened greater than the second and fourth syllable.

The third suggestion is, similar to that prosodic boundaries affect the lengthening in English(e.g., the left edge of the stress syllable attenuates lengthening greater than the right edge), prosodic boundaries in Standard Chinese influence the constraining spill-over effect of lengthening to outside of durational domain of lengthening. That is to say, the leftward spill-over effect of lengthening is less than the rightward spill-over effect of lengthening. Yiya Chen (2003) further investigate the utterance-final lengthening on four-syllable words of Standard Chinese and found out that greater utterance-final lengthening happens when the four-syllable words are in the sentence-final position than when they are in the sentence-medial position.

Last, an interesting suggestion by Shih & Ao (1997) indicates that there is no utterance-final lengthening effect in Standard Chinese. That means the word does not have longer lengthening in utterance-final position than in utterance-medial position.

Therefore, it is important to have further investigation of utterance-final lengthening in Standard Chinese.

Purpose and predictions

1. final lengthening

Final lengthening predicts that a word is longer in utterance-final position than in utterance-medial position. It is generally agreed that a same linguistic unit can have different durations in different contexts. Final lengthening is an obvious case of this effect. It has been found in a number of cross linguistic studies, for example, Dutch and English both have final lengthening. Moreover, Dutch and English also show the effects of focus lengthening, in English the two kind of lengthening is additive, while in Dutch it is not the case: when a word is in the utterance final position and it is being stressed, the magnitude of lengthening is less than the addition of final lengthening of a non-focused final word and the focus-induced lengthening of a focused word in a non-final position (Cambier-Langeveld 2000).

Most studies concentrate on the final syllable of the target word in the utterance final position in final lengthening, what's more the precise distribution within the final word has not been determined. Some studies that have been done so far discovered that although most of the duration increase occurs in the phrase-final syllable, statistically significant lengthening of 7-18% also occurs in the main-stress syllable, and the distribution of lengthening across the syllables of the final word is not straightforward in the sense that some regions appear to be skipped or lengthened less than the regions before and after them.(Turk et al., 2006). These findings elicit the following questions: where does the final lengthening begin, the stress syllable, or the final syllable? And which syllable is lengthened more. How much does they lengthened correspondingly?

In one study of standard Chinese, the results of a durational study on corpus data shows that there may not be utterance-final lengthening in Chinese (Shih &

Ao, 1997). This may due to the fact that their data are not carefully picked for the measurement of small durational effects.

In this study, we test whether final lengthening exists in bi-syllabic words in standard Chinese, where does the final lengthening begin, which part of is lengthened and how much does it lengthened, is the a progressive lengthening pattern in the distribution of final lengthening.

- **Where does the lengthening begin? And which syllables are lengthened? There are two hypotheses on the beginning of lengthening.**

Structural based hypothesis

On the structural based view, final lengthening affects a stretch of speech defined by linguistic structure (Turk et al. 2006). It is hypothesized that when a word is in the final position, the final-syllable rime, the stress syllable rime, and the rest subcomponent follow the lengthened part till the word boundary. This hypothesis suggests that the final lengthening is fixed to certain structural region, it proposes that final lengthening begins as early as the stress syllable.

Content based hypothesis

In addition to the structural based view, it is proved in several languages that lengthening of an earlier syllable occurs when the final syllable cannot be adequately lengthened. (Cambier-langeveld 1997) This induces that content-based hypothesis and other possible

hypotheses. In the content based view, the domain of lengthening is structurally variable, because its extent is influenced by properties of the last segment or syllable of the phrase. As for example, **expandability hypothesis** predicts that early lengthening appears because the final syllable is phonetically short, thus are not expandable. **Overlap hypothesis** the lengthening domain could be variable because a fixed lengthening gesture overlaps with a greater or lesser portion of the final word depending on the intrinsic length of its final segments (Byrd and Saltzman 2003). **Pi-gesture** concept which is based on the overlap hypothesis infers that its shape describes the time period during which the articulation of the segmental gestures that it overlaps with will be slowed, as well as how much they will be slowed. Then for words with intrinsic short final segments, the pi-gesture is more likely to overlap with earlier syllables in the final word and thus to show them down. As a result words with gesturally shorter and less complex final syllables (e.g. those containing lax vowels, high vowels or codas with only one consonant or even none) are more likely to show lengthening effects on earlier syllables. (Turk, 2006).

In this study the content based view is being tested, that final lengthening begins earlier when the final syllable is reduced otherwise the lengthening will be confined to the final syllable itself. Which can be explained both by the expandable hypothesis that earlier lengthening might occur when the final syllable is not expandable. And also by the overlap view that the phrase-final boundary is more likely to overlap with earlier syllable when the final syllable is intrinsically short.

It is predict that those target words with reduced second syllable and with stressed first syllable has earlier final lengthening effect, while

there is confined lengthening to the final syllable to final lengthening effect on words with full-vowel second syllable.

With words with initial stress, two different varieties of words are being compared, duration differences between words with reduced second syllable, and those have a full-vowel second syllable may show that early lengthening appears in when the second syllable is reduced, and confined to the final syllable when the final syllable is full.

- **Is there a pattern of final lengthening distribution once it begun?**

Progressive lengthening

How does the final lengthening distributed? An over simplified view suggest that all portion that are lengthened is lengthened at the same degree, however sever studies repudiate this hypothesis. In German when the stress is on the penultimate syllable, the final syllable lengthened most while the lengthening on the preceding main-stress syllable was not as much. (Kohler 1983). Other evidence also shows that when a word is in an utterance final position, final lengthening begins earlier than the final syllable, and it maybe progressive, the lengthening becomes progressively greater once it starts. In addition, progressive lengthening is also found within the final syllable when it is lengthened. Conversely a study on final lengthening of American English showed that the final lengthening effect does not appear in a contiguous domain. As the second syllable in some words like seems skipped from the final lengthening effect, or not lengthened as much as other syllables. This induces a weaker view of progressive lengthening which proposes that

final lengthening increases in magnitude across the segment and/or constituents that it does affect, but it might leave some intervening elements untouched. (Turk et al. 2006.)

In this study the progressive lengthening hypothesis is being tested here. It suggest that when a word is the in the utterance final place, the syllables within the word are lengthened progressively once the lengthening started. And when a word is lengthened, the subcomponents of the target word are lengthened progressively.

It is predicted that progressive lengthening exists in Chinese bi-syllable words, that once final lengthening starts, the successive syllable are lengthened progressively. And within the final syllable the subcomponent are lengthened progressively.

Given that target words in this study are two syllable words, comparison is being made between the first syllable rime and the second syllable rime; the first syllable rime and the second onset; and the second onset with the second rime in three different stress patterns.

2. Focus-induced lengthening

Focus-induced lengthening predicts a word is longer in focused position than in non-focused position. In English when a word is focused, all syllables within the word are lengthened (Cambier-Langeveld & Turk, 1999). Moreover, when only one syllable out of the word is focused, the whole word lengthens. (Cambier-Langeveld & Turk, 1999; Sluijeter, 1995.) Furthermore, multi-linguistic studies on focus lengthening show that the lengthening effect can be further analyzed in a sub-word level. In Swedish when a three syllabic word is focused, the lengthening effect extends to only one unstressed syllable that

followed the stressed one. (Heldner and Strangert 2001). Previous works on standard Chinese have shown that when a mono-syllabic word is focused, both onset and rime lengthened significantly (Chen, 2002, 2003; Shih & Ao, 1997). And when a bi-syllabic word is focused, both syllables are lengthened (Xu, 1999). When a multi-syllabic word is considered, and when the word is in utterance medial position, corrective focus induces robust lengthening (Chen, 2005). The results of the study show that when a focused domain is multi-syllabic, the distribution of lengthening is non-uniform: there is a strong tendency of edge effect with the last syllable lengthened the most. There is also spill-over lengthening on the neighboring syllables outside the focused constituent. And when the word is in the utterance final position the focus effect does not show as significantly as it is the utterance medial position.

In this study, focus-induced lengthening is being discussed in Chinese bi-syllabic words. And upon the existence of the focus-induced lengthening, does the word position influence focus induced lengthening? Are there differences of focus-induced lengthening on words in the utterance medial position than the final position? Is there more significant focus-induced lengthening effect when the target word is in the utterance medial position than in the utterance final position?

It is predicted that focus induced lengthening exists in standard Chinese bi-syllabic words, by comparing the duration of the target word in the stressed situation with the same word in the unstressed situation to see if there is obvious lengthening in the stressed version of the target words than the unstressed one.

Furthermore it is expected that focus induced lengthening plays a more important role when the target word is in the medial position than it is in the final position. Comparison of focus lengthening is made between target words in medial position and final position to see in which case it is lengthened more.

Still, does the stress pattern (first syllable stressed, second syllable stressed) of the target bi-syllabic word have any effects on the focus lengthening effect? Which part of the target word is lengthened in different word-types? Is there a progressive lengthening pattern in focus induced lengthening?

It is predicted that when a word is stressed, all parts of the target word are lengthened if they can. When the subcomponent is intrinsically short, then the lengthening will start earlier. And the lengthening is progressive with successive subcomponent of the target words lengthened more.

Methods

Materials

When a word is in an utterance-final position, the word tends to be longer than the same word in the medial position. Other than that, the sentence stress pattern (whether the word is stressed or not) together with the lexical stress pattern (which syllable of the word is stressed) have impacts on the lengthening effect too. Moreover the property of vowel (e.g. the vowel being intrinsically short) will affect the duration of the target words as well. In this study focus-induced lengthening and final lengthening will be discussed in Chinese two syllable words. Discussion is made about whether a bi-syllabic word in the utterance final position is longer than when it is in the utterance medial position. And whether it is longer when it is stressed than when it is unstressed. Further more when a word is lengthened, which syllables are lengthened, and which syllable is lengthened more?

An absolute durational comparison is made of the target word in the utterance-medial position with the word in the utterance-final position. As stated before, the stress pattern of the target words in an utterance has influence on the duration of the target words. In other words, target words are longer when they are stressed (focus-induced lengthening). To exclude the influence of focus-induced lengthening from the final lengthening we put the target words on different sentence stress patterns. Thus there are 4 combinations of situations of the target words. the target words that are stressed in the utterance-final position and in the utterance-medial position, target words that are left unstressed in the utterance-final position and in the utterance-medial position. Comparison is made between stressed words in different positions of the utterance, and unstressed words in the final position vs. unstressed words in medial position. if final lengthening is obvious in both cases, the hypothesis of final lengthening is proved in Chinese bi-syllabic words.

Since both the sentence stress pattern and lexical stress pattern have influence on the duration of the target word, we further discuss final lengthening in different lexical stress patterns. Chinese bi-syllabic words we choose in this study have 2 main different lexical stress patterns. Some are stressed on the first syllable; some have stress on the second syllable.

The property of the first syllable can be different in the target words with stress on the second syllable. A further division is made within this word type, by whether the first syllable is reduced or full. A comparison is then made between first syllable reduced words and full first syllable words with stress on the second syllable to see the influence of syllable property that plays in final lengthening effect.

For focus-induced lengthening, comparison is made between a stressed and an unstressed version of target words in the final position, a stressed and an

unstressed version of target words in the medial position. The division of word types is adopted in focus-induced lengthening to see the influence of word type in the focus-induced lengthening effect. .

Most Chinese words are either mono-syllabic or bi-syllabic. However mono-syllabic words are not adequate in analyzing the distribution of final lengthening or focus-induced lengthening. Thus two syllable words are chose here. .

Of all bi-syllabic words, it will be easier to fit words in the same position of the same background sentence pattern if they are of the same type. Therefore bi-syllabic titles are chose as the target words. In Chinese titles there are pairs like [daje] (with reduced last vowel); [dama] (with the first vowel being reduced); [dziefu] (with reduced last vowel); [dziemei] (with two full syllables); and also [didi] (reduced last vowel), while [dimei] (with reduced first vowel). They have the same first syllable, different properties of the second syllable, which is favored in the analysis of the final lengthening that based on the content based view: lengthening begins earlier than the final syllable when that syllable contains a reduced vowel. To test the structure based view which claims that final lengthening begins at the main-stress syllable. Final lengthening in words with different lexical stress patterns is discussed here. As for example [dama] has a stress on the second syllable; the word [daje], has a stress on the first syllable; [dimei] has a stress on the second stressed syllable. And [gəunpo] has a stress on the second syllable.

Final lengthening predicts that a word is longer in utterance-final position than in utterance-medial position. (Chen, 2005).To prove the existence of final lengthening in Chinese bi-syllabic words, the target words is put in different positions of the sentences, then comparison is made on the durations of the

subcomponents of the target words between utterance final position and the utterance medial position.

e.g. Target word: **didì**

Zhe shì tade **didì**. (utterance-final)

This is his brother.

Tade **didì** zou le. (utterance-medial)

His brother has gone.

As mentioned before, in Standard Chinese, when a bi-syllabic word is focused, both syllables are lengthened (Xu, 1999). By comparing the duration of the target words in different positions of the sentence, target words can be found longer in the utterance-final position than it is in the medial position. But this could be the role of focus-induced lengthening effects that plays on the target words when they are in the final places of the utterance: they are lengthened, not because of their utterance final position, but because they are being stressed. As a result, a control of the durational comparison should be made under certain sentence stress patterns. Durations of stressed words in final position compared with when they are in the medial position. Durations of unstressed words in final position compared with when they are in the medial position. Therefore we try to control the word stress pattern of the sentence to avoid the focus-induced lengthening in the final word. We repeat the two sentences but in a different way. First time, we focus on the target words. At the second time, we focus on the word “tade (his)” —the word before the target words.

e.g. Target word: **didì**

Utterance final position:

Background sentence:

Zhe shi ta de **didi**. (in this sentence “didi” is stressed)

This is his brother.

Target sentence.

Zhe shi **tade** didi. (here “ta” is stressed)

This is his brother.

Utterance medial position:

Background sentence:

Tade **didi** zou le. (“didi” is stressed here)

His brother has gone.

Target sentence:

Tade didi zou le. (“ta” is stressed here)

His brother has gone.

In order to make sure the stressed pattern of the target and background sentences from being mixed up with each other by the subject, questions as follow are initiated for the target sentences and the background sentences

1. Zhe shi tade tong shi ma?

This is his coworker?

Bu, zhe shi tade **didi**. (“didi” is stressed)

No, this is his brother.

2. Zhe shi shei de didi?
This is whose brother?
Zhe shi **tade** didi. (“ta’ is stressed.)
This is his brother.
3. Tade shen me ren zou le?
His who has gone?
Tade **didi** zou le. (“didi’ is stressed.)
His didi has gone.
4. Shei de didi zou le?
Whose didi has gone?
Tade didi zou le. (“ta’ is stressed)
His didi has gone.

Subjects

Three native speakers of standard Chinese mandarin participated in the experiment, two females and one male. They are all bilingual speakers of Chinese mandarin and an accented Chinese language. But they do speak good standard Chinese mandarin. None of the speakers had any self-reported history of speaking or hearing difficulties.

Recordings

As to keep the questions and the answers (which are the test sentences) in accordance with each other, also with the need for the three subjects to read the test sentences in a different random order from each other, test sentences were

typed on note cards for three times for each subject in different sequences with page codes underneath. And questions were typed three times too in different note cards for each subject with page code corresponding to their answers. So each subject had their own test sentence cards and the question cards, with page code to keep the questions and answers in reference to each other. The question sequences and the answer sequences are checked several times to make sure a “right” answer is applied to each question. Subjects answered the questions by reading the test sentences typed on the note cards when they hear the corresponding questions being asked. When subjects stumbled or when they missed the stress of a particular test word in the test sentences, they were asked to repeat the sentences again, of course the questions were repeated to them as well. Also subjects are asked to read the notes twice for a back up recording file.

In the experiment, there are 11 target words, each word has four sentence patterns, utterance medial stressed; utterance final stressed; utterance medial unstressed; utterance final unstressed. And there are 3 subjects. So we get 132 renditions available for analysis.

Measurements

Durational experiments are promising tools that allow for tight control of prosodic variables of interest, and can yield reliable durational measurements. (2006 Turk et. al) to prove the existence of final lengthening in Chinese, to have a research on small durational effects like the final lengthening it will be ideal if the context is being highly controlled.

Target words from Chinese titles that are easy for the segmentation work are picked in this study. The gestures used to produce successive speech sounds

overlap to a great degree, this overlap makes it especially difficult to determine the point where a phoneme ends and where the latter phoneme begins, however there are abrupt spectral changes coincide with the onsets and releases of oral consonantal constrictions for the production of stops, fricatives, and affricates. For this reason, words with phonemes that are easy for the segmentation, as oral stops: [p, b, t, d, k, g]; sibilant fricatives: [s, ʃ, z, ʒ]; affricates: [tʃ, dʒ] are preferred. Phonemes that are reliable to segment in some contexts, as nasal stops: [n, m] weak voiceless fricatives: [f, θ] are picked as well. Those phonemes need to be avoid are: central lateral approximants like [w, l, h]; weak voiced fricatives [v, ð], also voiceless and voiced consonants in homorganic clusters like [st], [mb]. Consonants in clusters sharing manner of articulation like [pk], [bt], [mn], [ʃ].

With rules above, target words being picked are: dama; daye; didi, dimei, gonggong; popo; gongpo; jiefu; jiemei; bobo; bofu. The start phonemes of the target words are oral stops like: [d] [p] [g] [b] which are relatively evident in the spectrogram, and affricates as [dʒ] which can be seen as sequences as stop+affricates that are easy to segment from former words in the target sentences. In the study, the words follow the target words in the utterance medial position are the same word start with [z] which also makes it easy for segmentation.

Problems during segmentation

1. The segmentation of daye, [daje]

To prove progressive lengthening, durations of both syllables of the target word need to be computed, also the onset and rime of each syllables. Therefore we need to separate syllables, the onset and the rime of both syllables apart. The

start phonemes of the second syllables are: nasal stop as [m] which also has abrupt spectral changes at both onset and closure; oral stops [d], [g], [p], [b] as mentioned before that are easy to segment; and weak fricatives [f] that can be identified by the start and closure of frication noise; with one exception, the phoneme [j], which is a vowel-like segment without much of an oral constriction if any and it therefore doesn't make sense to try to find the oral constriction interval for it. As it is not possible to separate the [j] from the former [a] and the [e] that followed, the closure of the first syllable or the onset of the second syllable can not be decided in this word. Then it is unlikely to prove progressive lengthening with this word. As it is not able to use it, the word *daye* is discarded from the experiment.

2. Gonggong in medial unstressed situation

During the segmentation, it appears that when the target word *gonggong* is in the medial position and not being stressed, the second [g] is pretty short compares to the target words in the final position and also to words in the stressed medial position, it is so short that the phoneme [g] (the second one) is almost omitted when subject 3 read it. It is reasonable for the second [g] being short, and also this is consistent with the focus lengthening and final lengthening hypothesis because the second syllable is reduced. However when the [g] sound is totally undetected in the spectrogram, it is impossible to separate the first rime from the second rime. It is not able to segment the end of the first syllable or the start of the second syllable from the spectrogram. The back up recording file of the target word *gonggong* pronounced by subject 3 is being checked, the result show that the [g] is not adequately pronounced either when the target word is unstressed in the medial position. If a repetition of a syllable sub-component is not measurable in one situation but not the other, the relevant word should be

removed from both conditions. Thus we have to exclude this word as well from our experiment.

3. Didi in unstressed medial position

Also the target word didi as subject 2 pronounce it, the onset of the second syllable, the second [d] are not adequately pronounced to be precisely separated from the spectrogram, however in the back up repetition recording of subject 2, the second [d] is detectable. So this token in the repetition file is adopted in the study instead of in the first copy of the word in the medial unstressed situation.

4. Stress patterns of target words

Most Chinese bi-syllabic words are pronounced in a way as the first syllable being stressed mainly or the second syllable being stressed mainly. There are basic rules about the pronunciation of Chinese bi-syllabic words. Of the two syllabic words, if the two syllables are structurally similar and are parallel in meaning then it should be pronounced with both syllables being stressed. Otherwise the stress should be put on the main meaning syllable. As for example, in the target words jiemei, the meaning for syllable jie and mei are: older sister, younger sister respectively which are similar in meaning, then this word should be pronounced with both syllables being stressed (There is still a tendency of the second syllable being the stress syllable.) In the word dimei which means wife of brother, di: brother; mei: (here means) wife; the first syllable is stressed. Other rule concerning with the target words is: when the two syllables are the same and the word being a noun, the first syllable is stressed as in didi the first di is stressed; otherwise the second syllable is stressed. As ganggang (adv.) the second gang is stressed.

With above the rules, words that have similar structure and similar meaning will have similar stress patterns. However there are always exceptions, as the word *dama*, it is a word with stress on the second syllable, while the word *daye* (which is both similar in the composition of the word, and both are nouns used to address people) has a different stress pattern. It has a stress in the first syllable. Unfortunately, no rule can be found to explain this phenomenon. It is an established usage. We do have *daye* with stress on the second syllable but that has a different meaning to this *daye* we are trying to test here.

And also the word *dimei*, the meanings of the two syllables are similar. They mean brother *di* and sister *mei*. They are parallel in meaning, but it is an established usage as well which means brother's wife so the second syllable is stressed instead of both syllables being stressed.

Unlike English words which have fixed stress patterns. Chinese words are quite flexible in the way the word is pronounced. According to a certain rule, a word is supposed to be pronounced in a certain way either the first syllable being stressed or the second one or both, but this is not always the case, people pronounce a word differently with different stress patterns randomly. As for example *dama* can be pronounced with both syllables being stressed. Also in some dialects the stress can be put on the first syllable (we are not going to discuss here on Chinese dialects.) however as long as they way people pronounce it doesn't affect the understanding of the word, it is acceptable. In our study, some subjects may pronounce the word *dama* as stress on the second syllable and a secondary stress on the first syllable. Therefore the difference of lengthening effects on the two words types (stress on second syllable, first syllable reduced as *dama* vs. first syllable being full as *gongpo*) will be subtle. Yet a division is made between the two kinds of words since it is still worth to see if there is any difference between these two kinds of words,

Of all the target words, we divide them into 3 kinds of stress patterns: those with stress on the first syllable: jiefu, didi, popo, bobo, (Daye and gonggong are being left out from further analysis.); With the stress on the second syllable, and a tendency of the first syllable is being reduced: dimei dama; with full first syllable and stress on the second syllable: and bofu, jiemei, gongpo.

5. End of voicing or end of F2.

In comparisons of phrase-final vs. phrase-medial materials, it is likely that a pause will occur after a phrase-final word. In these cases, the choice of segmentation criteria may have drastic implications for conclusions about the presence and/or magnitude of prosodic effects. (Turk et.al 2006)

In sample sentences when the target word is in the final position, utterance-final vowels often end in creaky voice in our study. Sometimes the utterance ends with widely spaced glottal pulses that give the auditory impression of the vowel, although they lack continuous formant structure. In cases like this, a segmentation criterion based on continuous F2 yields a much shorter vowel than one based on laryngeal activity. The difference can be as much as 100ms. This initiate the question: where is the end of the final word, the end of F2 or the end of voicing? Similar phenomenon has been found in Japanese. In a particular example, when compare the vocalic interval based on the laryngeal criterion with the vocalic interval based on continuous F2, the choice of segmentation criterion makes a difference of 227 ms in the estimated duration of the final vowel. (Turk , Shattuck-Hufnagel, 2006). However no matter what criteria we choose, we need to be consistent with all tokens in the experiment.

One possible way to solve this problem is to have two segmentation criteria of all target words in the final position. One is the end of F2; the other is the end of voicing. We then have two set of data, for the study on the final lengthening and focus-induced lengthening of the Chinese bi-syllabic words.

Analyses

Absolute duration comparison is made between the target words in the stressed utterance medial position and it in the final position. And an absolute duration difference between the target words in the unstressed utterance medial position and it in the final position. In prove of focus lengthening hypothesis. We compare duration of the target words in the final position between the stressed version and the unstressed version. And duration of the target words in the medial position between the stressed version and the unstressed version. With the expectation that target words in the final position is longer than words in the medial position. And target words are longer when it is stressed than it is unstressed.

Most studies assume that lengthening is concentrated in the final syllable. In the structural based view, lengthening begins at the stress syllable. In the content based hypothesis, early lengthening appears because the final syllable is phonetically short, thus are not expandable.

In the target words, it seems that if a syllable is phonetically short, this syllable will not be stressed. And then it is more likely that final lengthening will starts from the first syllable when the vowel of the last syllable is reduced, which is consistent with the structure based view. But which syllable is lengthened more?

And for all targets words with different stress patterns, what is the distribution of lengthening in different syllables, and the distribution of lengthening in onsets and rimes within syllables.

We predict that final lengthening exists in Chinese and within Chinese bi-syllabic words, successive syllables are lengthened more, also within the final syllables, successive subcomponents are lengthened more (progressive lengthening).

Final lengthening is measured by comparing the duration of the same target words in the utterance final place and utterance medial place of a same speaker under a same stress pattern. Focus lengthening is assessed by comparing the duration of the same target words when it is stressed and that when it is unstressed of a same speaker in the same position. In all of these statistical analyses we compare absolute durations, with the report of durational differences in both absolute and percentage terms.

The progressive lengthening hypothesis is measured by comparing the interactions between syllable-subcomponent types. Unlike the measurement of the final lengthening which compare the duration of a same word in different position of an utterance, the syllabic subcomponents are different when the comparison is made, also the properties of the subcomponent is different too, thus an absolute duration comparison does not work here. A proportional measurement of lengthening comparison is made here. Using a log transform of our duration measures allowed us to compare proportional, rather than absolute, lengthening on different segment types.

Results

Lengthening effect (boundary condition, and focus condition of the word)

	Second syllable stress, with reduced first syllable		First syllable stress		both syllables stress, with full first syllable	
	Final lengthening	Focus induced	Final lengthening	Focus induced	Final lengthening	Focus induced
Lengthening on First onset		*		*	P<.1	*
On First rime	*	*	*	*		*
On Second onset			*	P<.1	*	
On Second rime	*	*	P<.1			*
On Word		*	*	*	*	*
On Second rime'	*	*	*	*	*	*
On Word'	*	*	*	*	*	*

Table 1: Onsets, Rimes, syllables, and Target word which show statistically significant differences between utterance-final position and utterance-medial position, and those that show statistically significant difference between stressed pattern and unstressed pattern. It is indicated with * that differences are significant at the $p < .05$ level, and is indicated with “ $p < .1$ ” that tendencies are at $p < .1$ level. “Second rime”, “second syllable” and “word” are the second rime, second syllable, and the word in the “end of voicing criteria” respectively. “Second rime”, and “word” are second rime, second syllable, and the word in the “end of F2” criteria

In the following sections, results will be described separately for final lengthening and focus induced lengthening. In both lengthening effects, we further divide the results by our target word types: words with stress on the first syllable, words with stress on the second syllable and reduced first syllable, words with stress on the second syllable and full first syllable.

Final lengthening

As shown in table 1, it is clear that final lengthening exist in Chinese 2-syllable words. The results of final lengthening are consistent with our predictions in general except for a few exceptions.

Results show that final lengthening effect does not seem to appear continuously. This is not consistent with the view that lengthening becomes progressively greater once it starts. Here the weaker version of the progressive lengthening is studied. That lengthening increases in magnitude across the segments and/or constituents that it does affect, even though it may leave some intervening elements untouched. (Turk et al., 2006)

We have tested the progressive lengthening by making the following comparison:

1. the first rime vs. the second rime
2. the first rime vs. the second onset
3. the second onset vs. the second rime

1. For target words with stress on the second syllable and reduced first syllable.

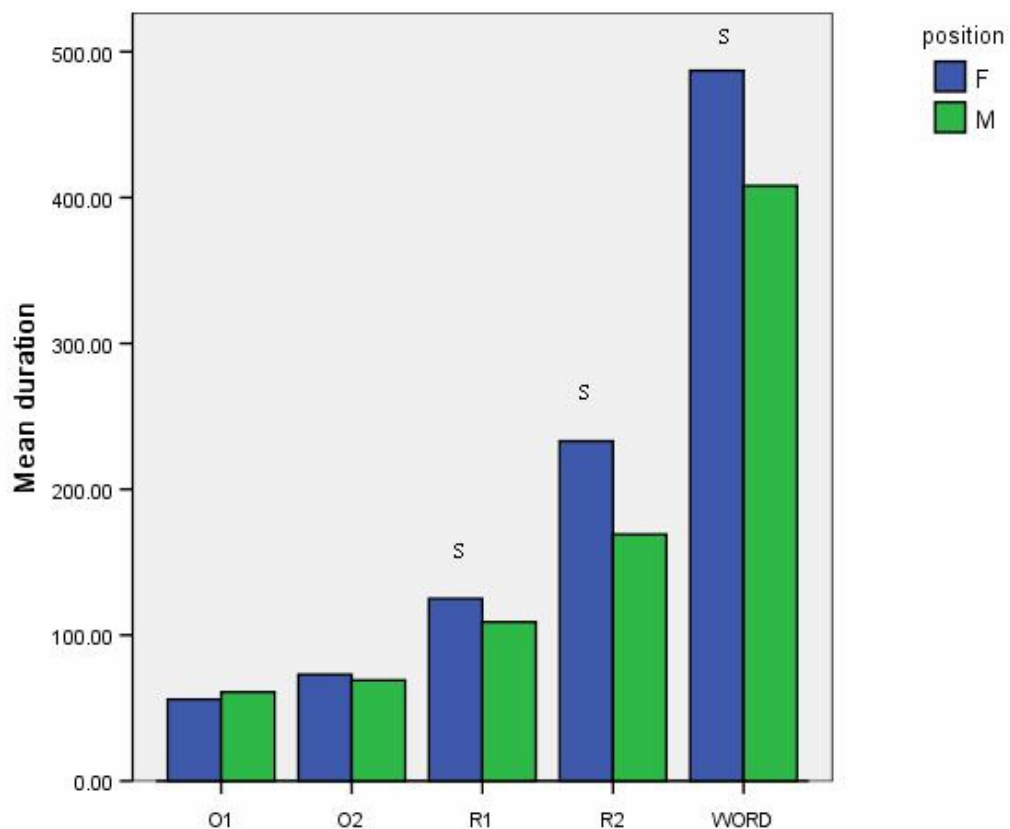


Figure 1. “s’ above bars show that the lengthening effect is significant. Mean duration comparison of final lengthening in words with stress on the second syllable, and a reduced first syllable.

- **Lengthening appears earlier than the stress syllable.**

According to the structural-based lengthening view, as we predicted, the target words should start lengthening from the stress syllable, which is the second syllable. The first syllable should be left without being lengthened adequately. There is significant lengthening effect on the first rime (16ms, 15%, $F(1,2)=57$, $p<.001$).

As stated before, target words with a main final stress normally contains a reduced first syllable. In English, the reduced syllable is left out from lengthening, as [i] in Tibet. However Chinese does not have a fixed stressed pattern as English. So people speak in a rather “random” way, as long as the word is recognizable. Each syllable or subcomponent of the syllable can be lengthened as much as it is needed.

In English, Dutch and some other languages, word-level stress plays a very important role, In SC, however, it is generally agreed that there is no word-level stress as that in stress-accent languages (Chen, 2000; Duanmu, 2000,) The target words we choose with stress on the final syllable are [dama] and [dimei]. Although these words are usually read with stress on the final syllable, it is discovered that in certain situations (for example, when the word is focused or when it is in the utterance final place), these two words can be read with both syllable stressed and with certain degree of lengthening.

● The “end of F2’criteria

The change of duration on the second rime is also significant when the “end of F2’criteria is considered. However the influence of duration change is not lengthening, but is shortening. The duration of the second rime is significantly longer in the medial place than in the final place. (19ms, 13% $F(1,2)=46$, $p<.001$). This may be determined by the choice of ending criteria. When the target words are in the medial place, they are not segmented with the “end of F2’criteria. On the contrary, it is more likely that the “end of voicing’criteria is adopted in the segmentation of the

target words in the utterance-medial position. The duration of the second rime can be much longer with the “end of voicing” than with the “end of F2”, so the duration of the final rime in medial position segmented by “end of voicing” can be longer than when in the final position segmented by “end of F2”.

It is also shown in table 1 that the target words do not have final lengthening effect with the “end of F2” criteria. This seems to be contradictory to the existing significant lengthening on both the first and second rime. But this is not so surprising because the “significant lengthening” effect on the second syllable is actually a “significant shortening”.

For these reasons, we don’t discuss final lengthening effect when the target words are segmented with the “end of F2” criteria.

- **Two syllables are not equally lengthened**

The lengthening effect of the second rime (“end of voicing” criteria) is of 64ms, 38% with $F(1,2)=49$, $p<.001$. The second rime is lengthened more than the first rime (with 19ms, 13% $F(1,2)=46$, $p<.001$). So although the syllable before the stress syllable is lengthened, it is not lengthened as much as the stress syllable. This gives some support to the content-based lengthening view. The differences in the lengthening of two syllables are caused by the properties of the two vowels, the reduced one lengthened less than the full one.

- **Progressive lengthening**

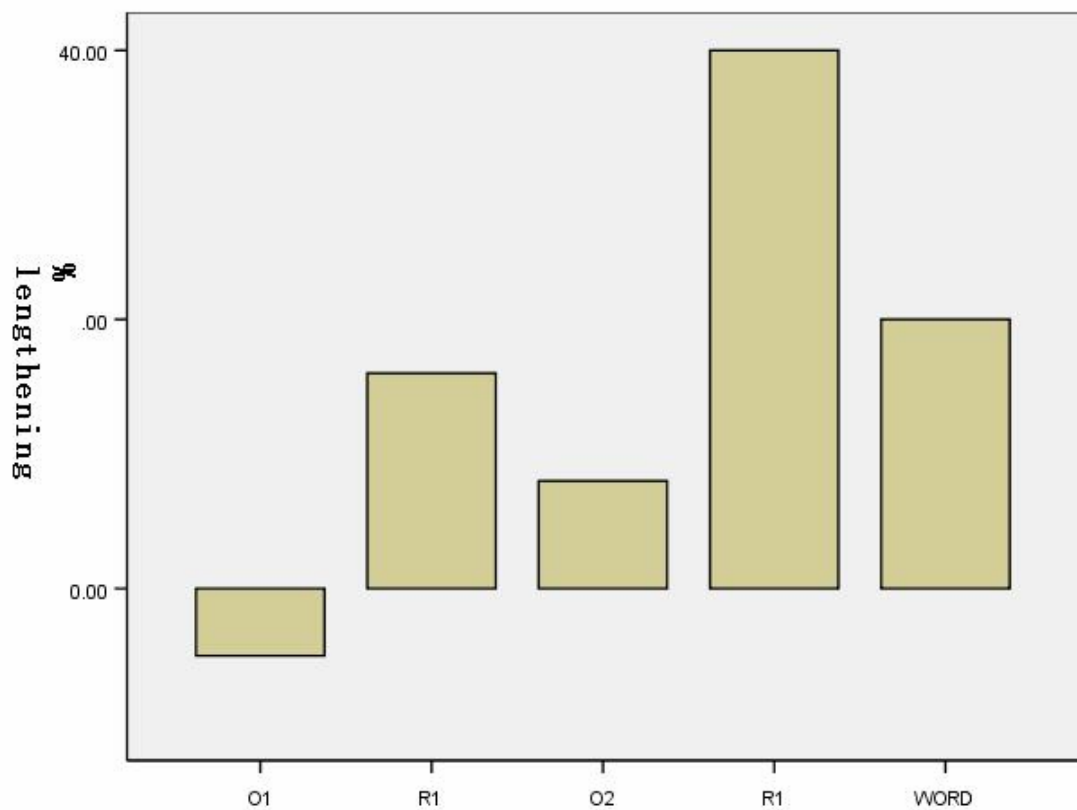


Figure 2. Progressive lengthening on words with stress on the second syllable and a reduced first syllable

As shown in the upper figure:

First rime vs. second rime:

$F(1, 2)=12$, $p<0.01$, there is significantly progressive lengthening for successive rimes in words with reduced first syllable and main second stress.

First rime vs. second onset, second onset vs. second rime:

The second onset is left un-lengthened here, which is consistent with the weaker version of the progressive lengthening view that lengthening is progressive. However it will leave some components unaffected.

To sum up, progressive lengthening exists in words with stress on the second

syllable and with reduced first syllable.

2. For target words with stress on the first syllable

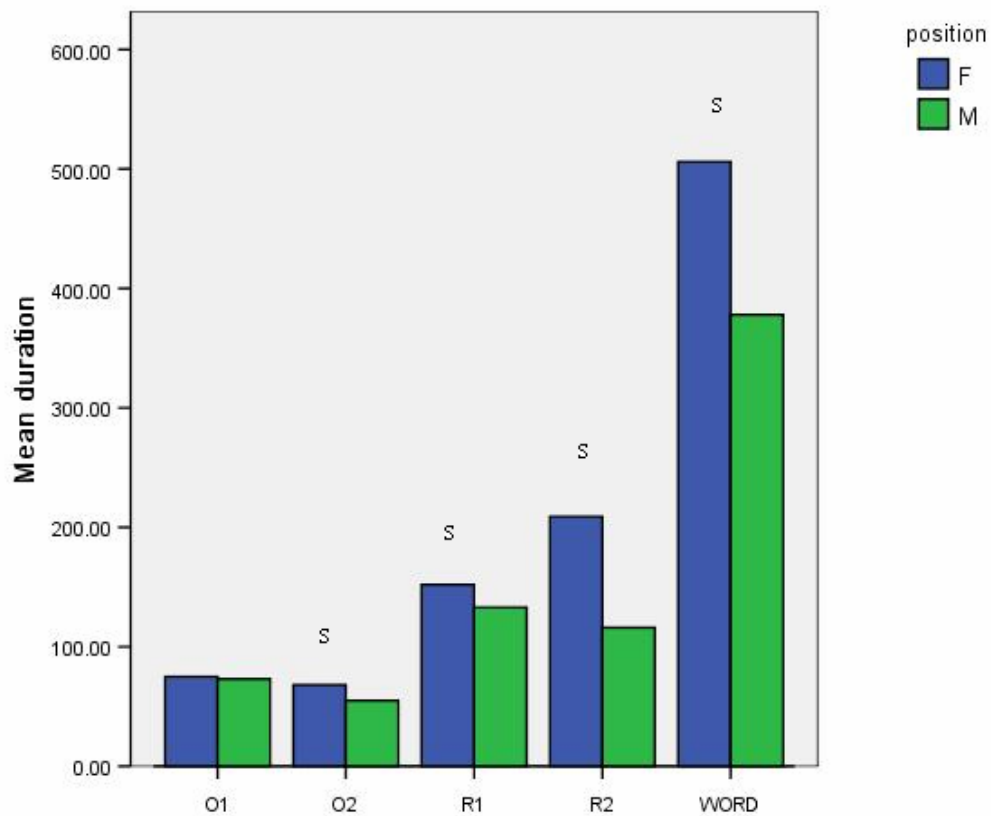


Figure 3. Mean duration comparison of final lengthening in words with stress on the first syllable, and a reduced second syllable.

● Lengthening on the first rime

For target words with stress on the first syllable, the first rime is lengthened at (30ms, 23% $F(1,2)=18$, $p<.001$). The target words with stress on the first syllable show a stronger lengthening effect on the first rime than the target words with stress on the second syllable, and a reduced first syllable (19ms, 13% $F(1,2)=46$, $p<.001$). In addition, the target words with stress on the first syllable show a stronger

lengthening effect on the first rime than those with second stressed syllable and with full first vowel. This could be a hypothesis of the pi-gesture theory, which suggests the first vowel of words like [didi] is lengthened more than words such as [dʒiemei] because the second syllable of the word [dʒiemei] is more expandable than the second syllable of the word [didi]. Therefore the first syllable of [didi] is lengthened more than the first syllable of the word [dʒiemei].

- **Lengthening on the second onset**

The lengthening effect on the second onset is of (12ms, 22% $F(1,2)=13$, $p=.001$). This shows a significant lengthening, which owns to the existence of a reduced second rime. It pushes the lengthening to start earlier in the onset of the second syllable. This is consistent with the content-based lengthening view that proposes that lengthening starts earlier if final rime is intrinsically short.

- **Lengthening on the second rime**

The lengthening on the second rime is significant too at (92ms, 79% $F(1,2)=181$, $p<.001$)

- **Progressive lengthening**

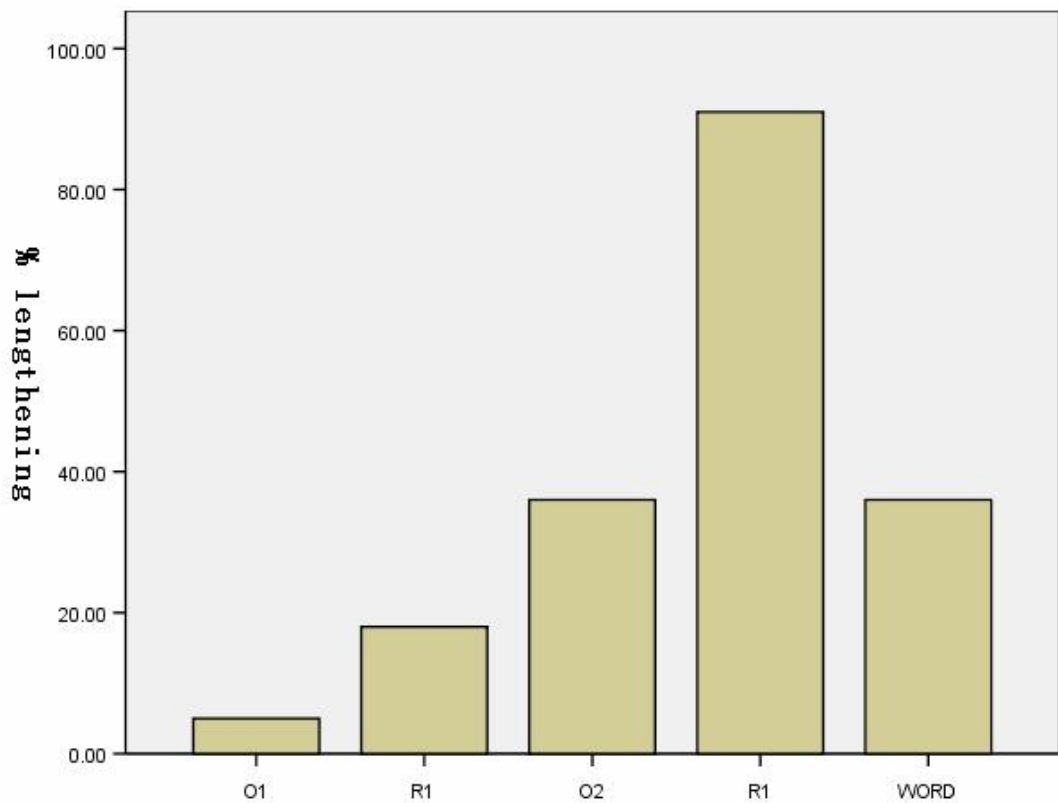


Figure 4. Progressive lengthening on words with stress on the first syllable and a reduced second syllable

As shown in figure 4, the progressive lengthening effect is rather obvious.

First rime vs. second rime:

$F(1,2)=36$ $p<.001$, consistent with progressive lengthening hypothesis.

First rime vs. second onset

No significant progressive lengthening.

Second onset vs. second rime

$F(1,2)=9$ $p<.01$, agrees with progressive lengthening.

In summary, progressive lengthening exists in words with first stress and

reduced second syllable.

3. For target words with stress on second syllable and with full first syllable.

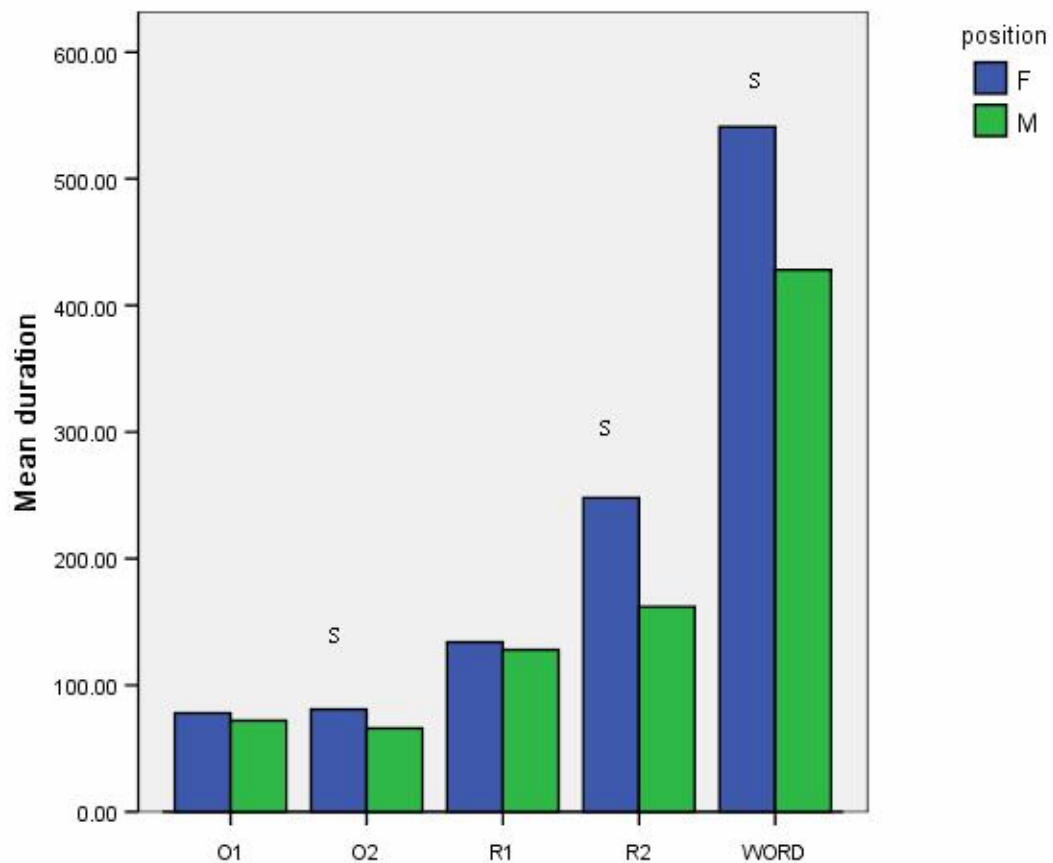


Figure 5. Mean duration comparison of final lengthening in words with stress on the second syllable, and a full first syllable.

- **No lengthening on the first syllable**

A tendency of lengthening appears in the first onset of words with stress on the second syllable and with full first syllable. (5ms, 7%, $F(1,2)=4$, $p<.1$). And no lengthening appears on the first rime. This is consistent with the structure based view

that lengthening starts on the stressed syllable.

The lengthening effects on the second onset and the second rime is significant at (14ms, 21% $F(1,2)=19$, $p<.001$), and (87ms, 54% $F(1,2)=97$, $p<.001$) respectively.

- **Progressive lengthening**

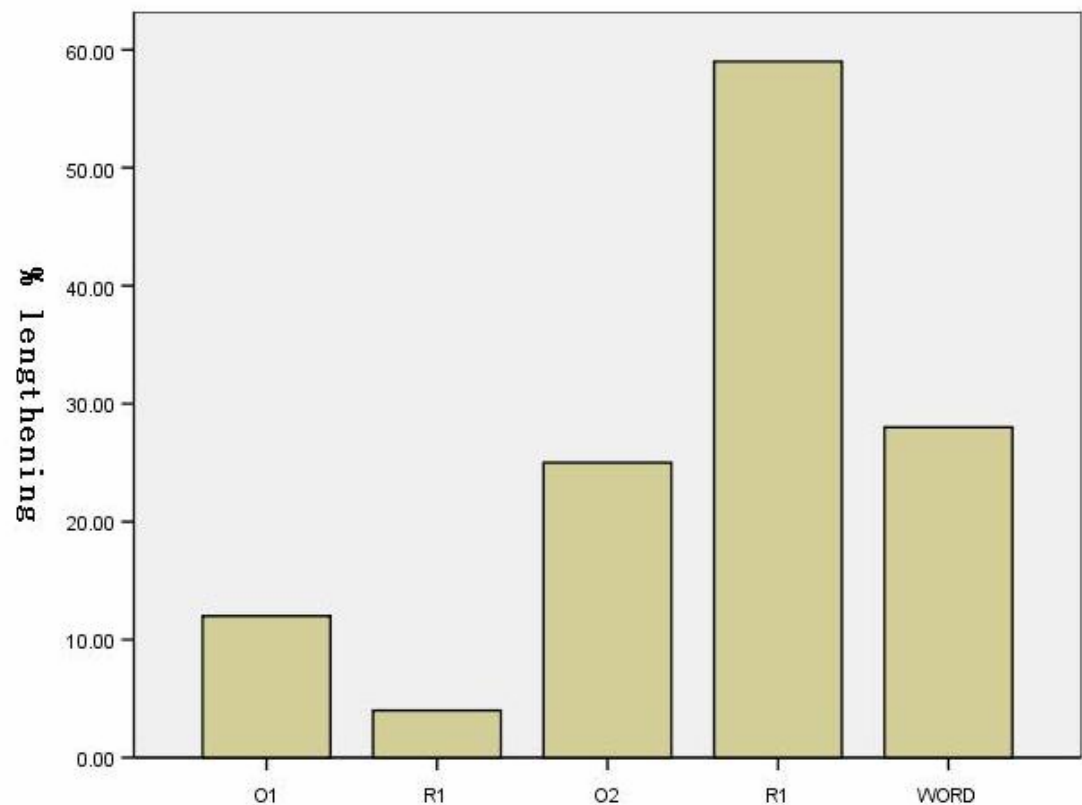


Figure 6. Progressive lengthening on words with stress on the second syllable and a full first syllable

In this type of words, the first syllable is left out from lengthening. To prove the progressive hypothesis, we need only to compare the second onset with the second rime.

$F(1, 2)=21$, $p<0.001$, progressive lengthening presents here as well.

Focus lengthening

From table 1, we can see that, in Chinese 2-syllable words, when a word is focused, both syllables are lengthened. And all subcomponents of the word are lengthened except for the second onset. However there is still a tendency of lengthening on the second onset of words with stress on the first syllable and with a reduced second vowel.

In the study of focus induced lengthening, the two criteria of segmentation for the words on the final position are both applicable here. Because whenever there is an unstressed target word segmented by the “end of F2” criteria in the final place, there will be a counterpart of a stressed version. Since we investigate the difference of the unstressed and the stressed version, it makes no difference no matter what criteria is used as long as both the criteria used are consistent through all target words.

1. For words with stress on the first syllable and a reduced second vowel

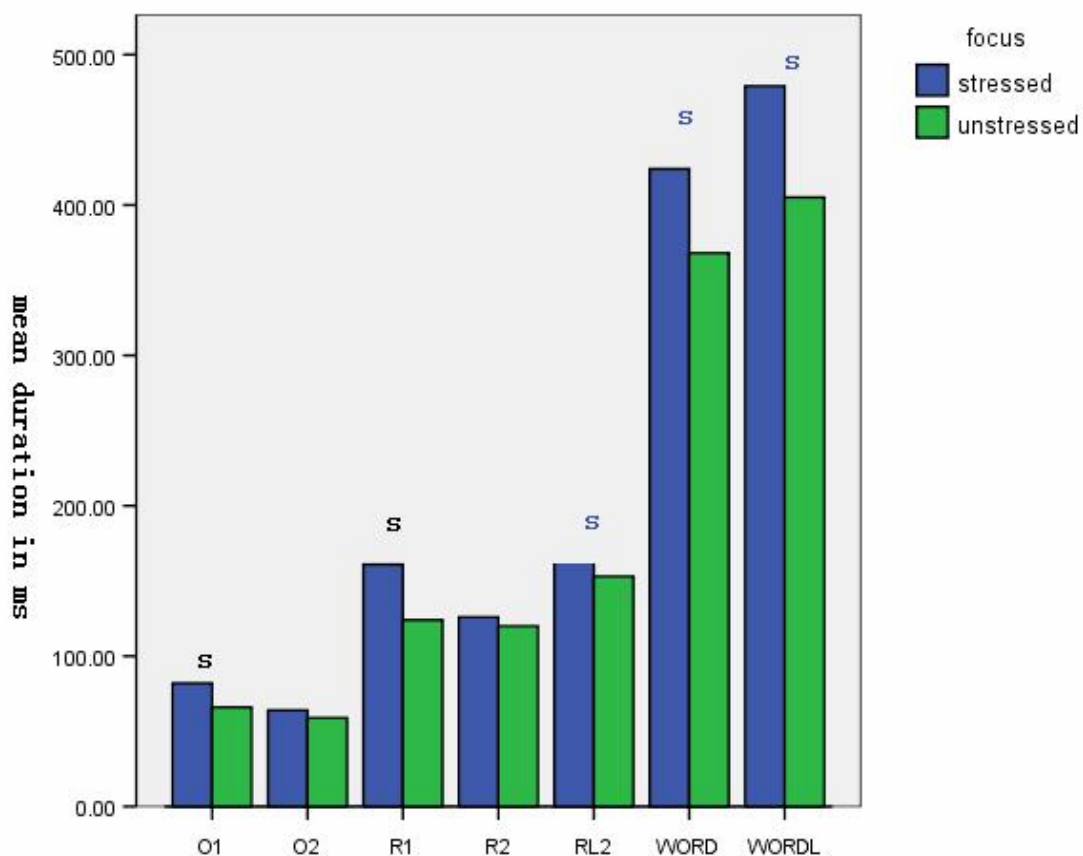


Figure 7. RL2 and WORDL are the rime 2 and the target word segmented with the “end of voicing” criteria correspondingly. Mean duration comparison of focus-induced lengthening in words with stress on the first syllable, and a reduced second syllable.

● Difference of lengthening on the onsets

As it is shown in figure 7, Lengthening is significant in the first onset (13ms, 25% $F(1,2)=7.546$ $p=.023$). In addition, there is a tendency of lengthening on the second onset (5ms, 8% $F(1,2)=4.013$). In target words of other types, there is no significant lengthening at all on the second onsets.

The reason of this difference between the first onset and the second onset may be explained by the fact that, when a Chinese word is stressed, a stress will be added to the first syllable, thus there will be a significant lengthening on the

first onset. For the second syllable where there is no such impact, no extra stress is added to the second onset.

There is a tendency of lengthening on the second onset of words with a reduced vowel. Nevertheless no lengthening appears on the second onset of other types of words. This suggests lengthening begins earlier with an un-expandable reduced vowel, which is consistent with the content-based view.

- **Lengthening of the laryngeal activity on the second rime**

There is no significant lengthening on the second rime under the “end of F2’ criteria, because the intrinsically short syllable cannot be adequately lengthened. However significant lengthening appears on the second rime when segmented by the “end of voicing’ criteria. (18ms, 12%, $F(1,2)=10.779$, $p=.004$)

From this, it can be seen that, when the target word is stressed, the second rime in the final position is significantly lengthened under the “end of voicing’ criteria, while no significant lengthening appears under the “end of F2’ criteria. Thus it can be inferred that, when a bi-syllabic word with second reduced rime is stressed in the utterance final position, the laryngeal activity is lengthened.

- **Lengthening effect on other subcomponents**

First rime: 38ms, 31%, $F(1,2)=75.779$, $p<.001$

Word (end of F2): 66ms, 18%, $F(1,2)=47.165$, $p<.001$

Word (end of voicing) 74ms, 16%, $F(1,2)=62.496$, $p<.001$

2. For words with stress on the second syllable

As shown in table one, for words with stress on the second syllable, there

seems to be no difference on focus lengthening between target words with a reduced first syllable and those with a full syllable.

- **For words with a reduced first syllable and stress on the second syllable**

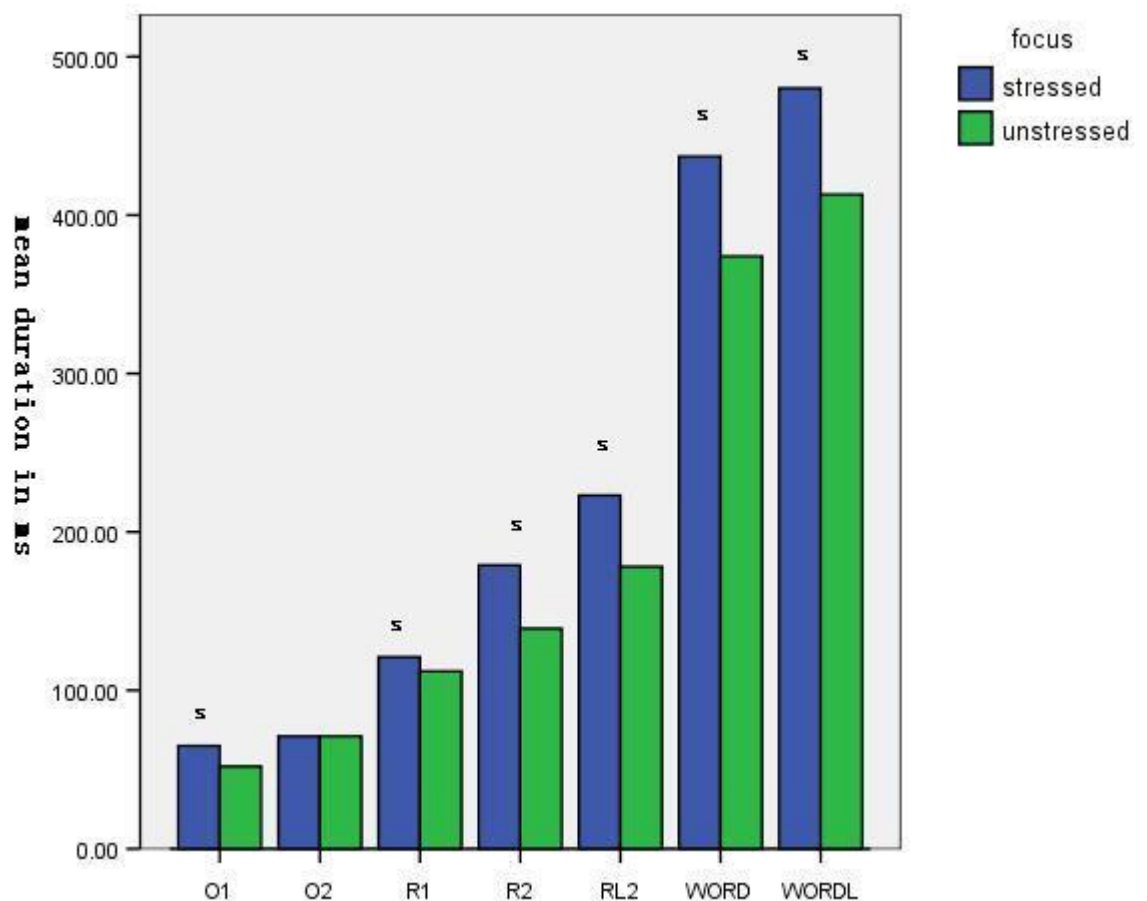


Figure 8. Mean duration comparison of final lengthening in words with stress on the second syllable, and a reduced first syllable.

Significant focus-induced lengthening effects:

First onset: 13ms, 25%, $F(1,2)=7.546$, $p<.05$

First rime: 9ms, 8%, $F(1,2)=27.326$, $p=.001$

Second rime (F2): 40ms, 29%, $F(1,2)=211.862$, $p=.000$

Second rime (voicing): 44ms, 25%, $F(1,2)=28.383$ $p=.000$

Word (F2): 63ms, 17%, $F(1,2)=85.030$, $p=.000$

Word (F3): 67ms, 16%, $F(1,2)=30.999$, $p=.000$

- **For words with full first syllable and stress on second syllable.**

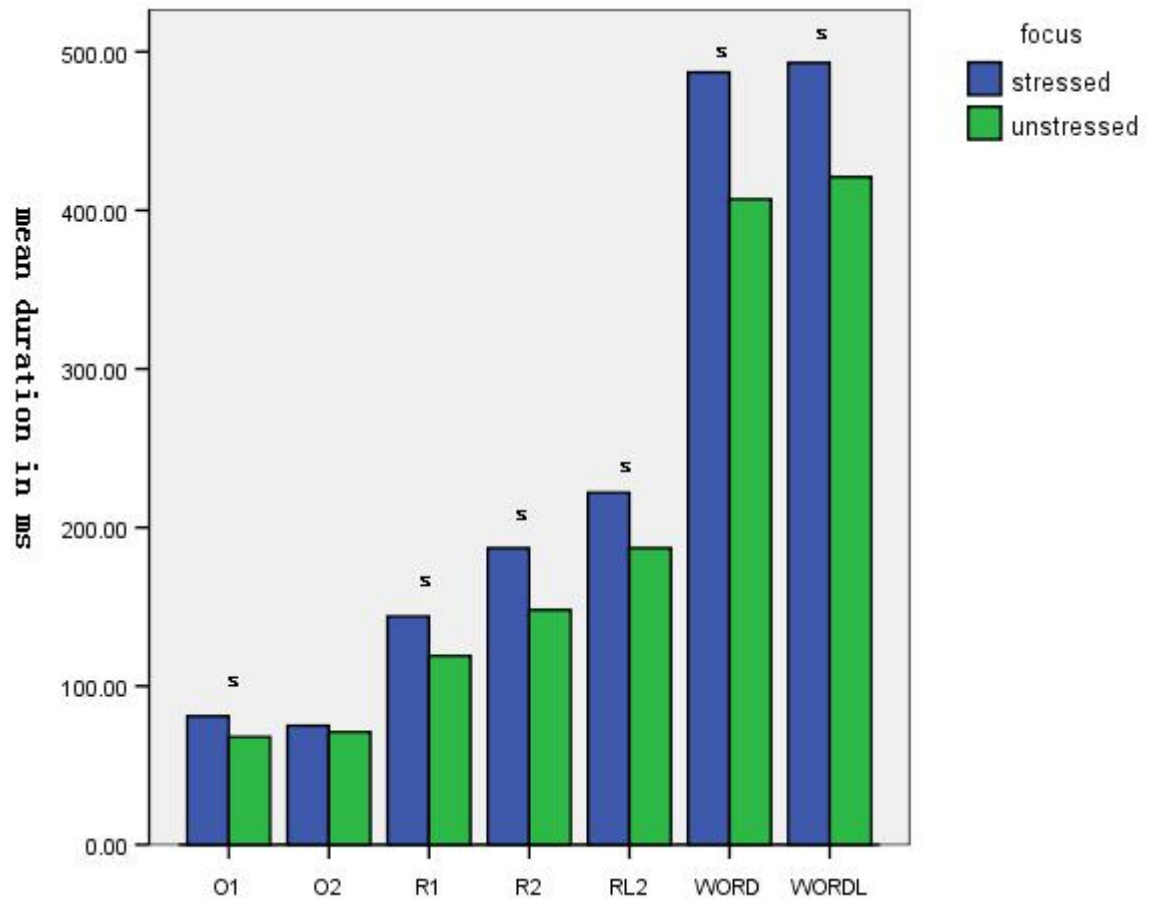


Figure 9. Mean duration comparison of final lengthening in words with stress on the second syllable, and a full first syllable.

Significant lengthening effect:

First onset: 12ms, 17%, $F(1,2)=8.865$, $p=.009$

First rime: 25ms, 21%, $F(1,2)=59.598$, $p=.000$

Second rime (F2): 39ms, 26%, $F(1,2)=41.462$, $p=.000$

Second rime (voicing): 35ms, 19%, $F(1,2)=17.473$ $p=.001$

Word (F2): 40ms, 120%, $F(1,2)=71.462$, $p=.000$

Word (F3): 75ms, 17%, $F(1,2)=54.907$, $p=.000$

- **Summary of focus-induced lengthening on words with second main syllable:**

Focus lengthening appears on all subcomponents of the target words except the second onset. (The reason is similar as discussed before).

There is difference between the lengthening on the first syllable of target words with reduced first syllable and the lengthening on first syllable of target words with full first syllable, First onset: 13ms, 25%, $F(1,2)=7.546$, $p<.05$; First rime: 9ms, 8%, $F(1,2)=27.326$, $p=.001$ vs. First onset: 12ms, 17%, $F(1,2)=8.865$, $p=.009$; First rime: 25ms, 21%, $F(1,2)=59.598$, $p=.000$. Thus although both first onset and first rime is lengthened, the first rime (the reduced vowel) is lengthened less than the full first rime.

3. Progressive lengthening?

	Reduced first syllable, stress on second syllable	Stress on first syllable	Full first syllable, stress on the second syllable
First onset	13ms, 25%	16ms, 25%	12ms, 17%
First rime	9ms, 8%	38ms, 31%	25ms, 21%
Second onset			
Second rime(F2)	40ms, 29%		39ms, 26%
Second rime(voicing)	44ms, 25%	18ms, 12%	35ms, 19%

Table 2

From table 2, there shows now progressive lengthening in focus induced lengthening.

4. Word position effect on focus lengthening

As predicted, when the word is in the utterance final position, the focus effect does not show as significantly as when it is the utterance medial position.

Results show that word position has influence on the focus induced lengthening.

With ($F=50$, $p<.001$) on the total duration of the target word when the second rime in the final position is segmented in the “end of voicing” criteria.

With ($F=7.429$, $p=.01$) on the total duration of the target word when the second rime in the final position is segmented in the “end of voicing” criteria.

With ($F=50$, $p<.05$) on the second rime when it is segmented in the final position in the “end of voicing” criteria.

With ($F=4.19$, $p<.05$) on the first rime.

The difference is presented in the following table.

	Utterance final	Utterance medial
Word(voicing)	56ms, 12%	89ms, 25%
Word(F2)	50ms, 12%	90ms, 22%
Second rime(voicing)	23ms, 11%	35ms, 28%
First rime	25ms, 20%	32ms, 26%

Summary of results.

1. final lengthening

Final lengthening effect exists in those three types (stress on the second syllable with an short first syllable, stress on the first syllable with a short second syllable, stress on the second syllable with a full first syllable) of Chinese bi-syllabic words, in that intrinsically short syllables are lengthened less than full syllables.

The lack of lengthening on the first syllable of words with stressed second syllable and a full first syllable is consistent with the structural based view that lengthening starts from the stressed syllable. In Chinese bi-syllabic words, when the first syllable is full, it is likely that there is not much space left for lengthening in normal speech. However, in target words with stressed first syllable and reduced second syllable, there is significant lengthening on the first stressed syllable. The final lengthening difference in these two categories of words can be explained by the pi-gesture theory. The first syllable of words with a full second syllable is lengthened less than the first syllable of words with a reduced syllable, because the reduced syllable is unlikely to be lengthened as much as the full one.

The final lengthening distribution pattern is consistent with the weaker version of the progressive lengthening hypothesis. That is, the final lengthening is progressive with some subcomponents being left from lengthening the first syllable lengthened less than the second syllable, and the onset is lengthened less than the rime within the second syllable,

2. Focus induced lengthening.

The focus-induced lengthening is quite consistent with our predictions.

When a word is focused, all parts of the subcomponents are lengthened except the second syllable that is left out from the lengthening process. A possible reason for the absence of lengthening on the second syllable could be: when a word is focused in Chinese, there will be an extra stress added to the first syllable, thus lengthening occurs in the first onset. However there is no such effect on the second syllable, thus the second syllable is being left out from lengthening.

No progressive lengthening effect is detected in focus induced lengthening. This can also be explained by the 'extra stress' hypothesis. The first onset is so significantly lengthened because of the appearance of the extra stress on the first syllable.

Word position has an obvious effect on the focus induced lengthening. When the target words are in the utterance medial position, the focus lengthening effect is stronger than when they are in the utterance final position. It can be explained that, when they are in the utterance final position, the target words have greater final lengthening than when they are in the utterance medial position, hence there is not much space left for focus lengthening. From this, it can be inferred that in Chinese bi-syllabic words, final lengthening and focus-induced lengthening are not additive. In other words, the final lengthening effect on a focused word is less than the final lengthening effect on a non-focused word. The focus-induced lengthening effect on a final word is less than the focus-induced lengthening effect on a non-final word.

Conclusions

The study of utterance final lengthening effects and the focus induced lengthening effects on 3 different word types in standard Chinese has revealed both similarities and differences compared to earlier studies in German, Dutch, Hebrew, Estonian, Southern British English and American English. And there are also differences and similarities compared with other studies in Chinese as well. Basically the lengthening distribution pattern of the final lengthening is consistent with the hypothesis of progressive lengthening, with the final rime lengthened most. For focus-induced lengthening there is no distribution of lengthening pattern, and there is a position effect on the focus lengthening in that focus lengthening is greater when the target words are in the utterance medial position than it is in the final position.

As only 3 types of words are adopted here, it will be important to have more studies in structurally more complex Chinese words for the discovering of the lengthening effects.

Acknowledgements

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